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Softening of Circulating Water in the Cooling System of Mine Compressor Devices

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Abstract: Today, a number of significant shortcomings of the cooling system have been identified in the use of mining compressor devices all over the world, which are caused by the specific features of their working principle. Thus, not cooling the air in reciprocating compressors every 5-6℃ increases the electricity consumption for air compression by 1%, and the efficiency decreases by 8-10%, causing a significant economic loss in the production of compressed air.

In this regard, there is a need to study the effect of the cooling quality of the compressed air on the efficiency of the compressor device, to improve the cooling system, to develop a device for softening the supply water, to develop the scientific basis for increasing the efficiency of mining compressor devices.

Key words: compressor, cooling system, compressed air, heat transfer, layer (nakip), intermediate cooler, water softening, coal sorbent, air cooler, artificial cooling.

The operation of mining compressors in the mining industry is one of the energy-consuming processes that require resource conservation. The share of compressor devices that produce compressed air as pneumatic energy in the balance sheet of mining enterprises is 20-35%, and its further improvement affects the performance of further technological processes. The widespread use of compressed air requires the development of effective technical solutions during the production of compressed air in industrial enterprises and the need to reduce operating costs by increasing the energy efficiency of compressor devices [1,2].

Analytical studies on the operating efficiency of reciprocating mining compressors show that most of the compressors used in mining enterprises work with less efficiency than indicated in the technical passport, and the consumption of electricity is relatively high.

The decrease in the efficiency of mining compressors and leaks in the network lead to a decrease in compressed air pressure, as a result of which the actual (real) power of pneumatic energy consumers is reduced by 25-45% of the nominal value [3].

The performance indicators of the compressor cooling system have a lot of influence on reducing the production efficiency and increasing the energy consumption of mine compressor devices.

The significant disadvantages of the cooling systems of mining compressor devices are caused by the characteristics of their operation, in particular, the dustiness of the atmospheric air supplied to the compressor, the high hardness of water, the length of the main pipe networks, as a result of which special requirements are placed on the operation of the cooling system of mining compressor devices. In addition, due to the lack of clean fresh water, water with a high content of salts and various impurities is used in the cooling system, which worsens the performance of intermediate and final coolers.

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The effectiveness of the cooling system of mining compressors can be improved by developing effective methods of preventing the formation of deposits (layers) on the heat exchanger surfaces of intermediate and final coolers [5].

In cooling towers, a part of cooling water is lost due to dripping and evaporation, in some cases water loss compensated by supply (additional) water is 20-30% during one day.

As a result of the work of the circulating system, the evaporation of part of the water, as well as the constant addition of supply water, the concentration of dissolved salts in the water gradually increases. One of the best solutions to prevent the formation of a sediment layer on the surfaces of heat exchangers of compressor units is to use filtered water as a circulation, but this requires constant filtration of the supplied supply water [6].

A supply water softener was developed for effective filtration of supply water added to the cooling system of compressor devices.

The basis of this device is a filter consisting of a filter material, shown in Fig. 1. As a filter material, it is recommended to use bentonite-coal sorbent, which can be regenerated many times (up to 7-8 times). After recovery, the charcoal sorbent does not lose its original properties.

Figure 1. Granulated bentonite-coal sorbent

During the experimental testing of the developed filter, it was found that the efficiency of water purification is higher at a higher temperature of the filtered water. Therefore, when entering the filter, the water is heated in a heater, and when leaving the filter, the water is cooled back, so a heat exchanger is used as a heater and cooler.

Figure 2 presents a general view of the device that softens the supply water of the cooling system of compressor devices.

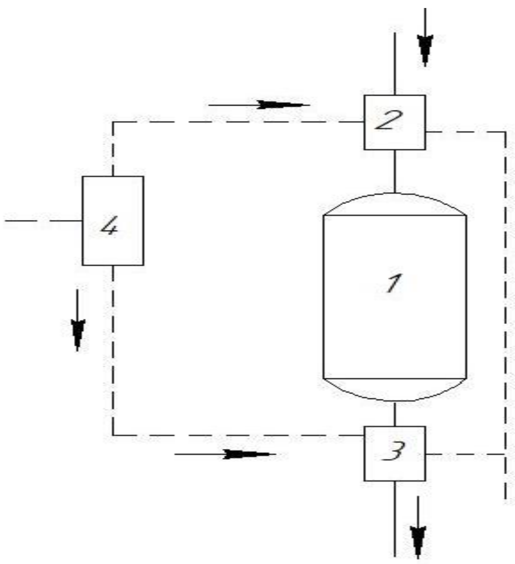

Figure 2. Supply water softener.

1 – filter with charcoal sorbent; 2 – water heater; 3 – water cooler; 4 - rolled pipe

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Heating and cooling of supply water requires significant energy costs, in this regard, in order to reduce energy losses, water heating and cooling is carried out by a spiral (vortex) pipe, the principle of operation of which is based on the effect of separation of air temperature by scrolling.

Figure 3 shows an overview of the cooling system of the compressor units during the installation of the supply water softener.

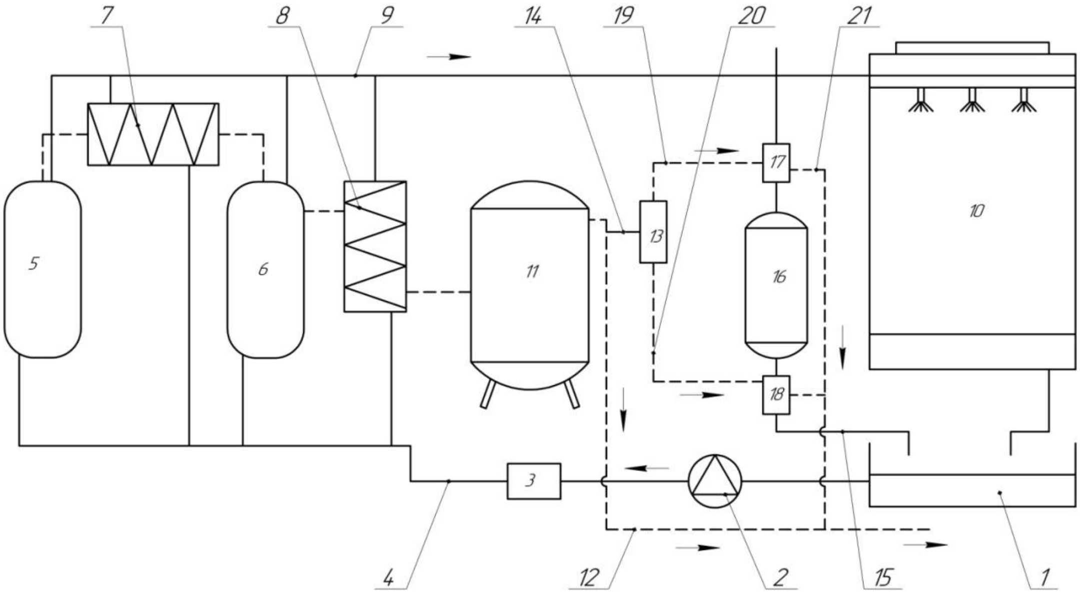

Figure 3. General schematic view of the cooling system of compressor units with a supply water softener.

1-quencher; 2-pump; 3-electromagnetic water treatment device;

4-cooling water pipes; 5-the first stage of the compressor;

6-the second stage of the compressor; 7-intermediate cooler;

8-last cooler; 9-heated water pipes; 10-water tower;

11-compressor receiver; 12-pipe supplying compressed air to the consumer; 13-rolled pipe; 14-pipe; 15-water supply pipeline; 16-filter; 17-water heater; 18-water cooler, 19-hot air flow pipe; 20-cold air flow pipe; 21 - pipe.

After installing the supply water softener, the cooling system of mine compressors works as follows (Figure 3). When the cooling system is working, the circulating coolant in the cooler (1) is transferred by the pump 2 through the pipe 4 to the intermediate heat exchanger 7, the final heat exchanger 8, as well as the first stage of the compressor (5) and the second stage of the compressor (6), before transfer is passed through an electric magnetic processing apparatus. Water, during cooling of the compressor and heat exchanger stages, heats up and is supplied to the cooling tower (10) through pipe 9 for further cooling. The water heated in the cooling tower (10) is cooled and discharged to the clarifier (1) and then the whole process is repeated. During the cooling process, some of the water in the cooling tower (10) evaporates and decreases in volume. To compensate for the lost volume of cooling water, supply water is supplied to the quencher from pipe (15).

A carbon sorbent filter 16 is installed in the supply water pipeline (15) to clean the supply water from various impurities and hardness salts. The feed water is heated in the heater (17), then softened in the filter (16), and cooled in the cooler (18) before passing to the softener.

The supply water is heated and cooled at the inlet and outlet of the filter using hot and cold air flow from the coiled pipe. The compressed air in the receiver (11) is transferred to the pipe (12) to supply compressed air to the consumers, a part of the compressed air in the pipe (12) is

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transferred to the rolled pipe (13) through the pipe 14. The compressed air passes through the coiled pipe 13 and is divided into a hot stream directed to the heater (17) along the pipe 19, and a cold stream directed to the cooler (18) along the pipe 20. Hot and cold air streams leave the heater 17 and the cooler (18), are mixed in the pipe (21), transferred to the pipe (12) and then transferred to the consumer.

The softener of the supply water of the cooling system of the recommended compressor units allows cleaning the compressor cooling water from salts and any impurities, thus preventing the formation of a deposit layer on the heat exchanger surfaces, which increases the efficiency of the compressor units.

Based on the results of experimental studies of the developed supply water softener, it was determined that the reduction of the total hardness of softening water depends on its temperature.

Figure 4 shows that the reduction of the total hardness of softening water depends on its temperature (t).

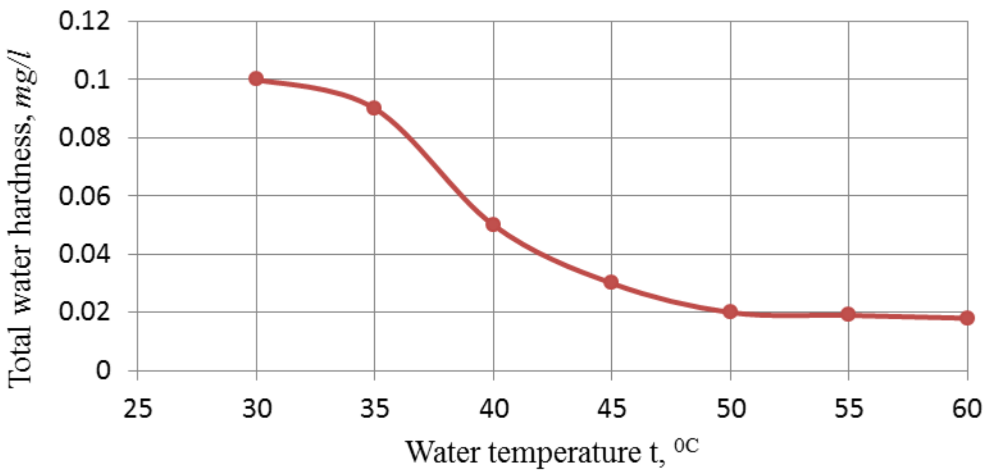

Figure 4. Reducing the total hardness of softening water depends on its temperature

The results of the experimental studies presented graphically in Figure 4 show that the highest efficiency of water softening is achieved at a water temperature of 50-60°C.

During the softening of water with a total hardness of 0.21 J mg/l and a temperature of 30 0 C, the total hardness of the softened water leaving the filter was 0.1 J mg/l. A decrease in hardness was observed with increasing water temperature, and the total hardness of the water leaving the supply water softener decreased by 0.02 J mg/l when the water temperature increased to 50°C.

The developed compressor devices can effectively filter the supply water added to the cooling system in the softener of the supply water of the cooling system. The basis of the supply water softener is a bentonite-coal sorbent filter made of inexpensive local raw materials, which can be regenerated several times. The regenerated carbon sorbent does not lose its original properties.

Based on the conducted research, it was determined that the reduction of the total hardness of the softening water in the water softening device of the compressor cooling system depends on its temperature.

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